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PRECISION PLANTER AND FERTILIZER APPLICATOR FOR USE ON EXPERIMENTAL PLOTS

Miscellaneous Publication No. 962

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PRECISION PLANTER AND FERTILIZER APPLICATOR FOR USE ON EXPERIMENTAL PLOTS

by

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INTRODUCTION

Agronomists need a planter that can meter seed accurately and an attachable fertilizer applicator that can meter fertilizer at specified rates for use on experimental plots. A study showed that no available machine had all the predetermined operating characteristics required in a precision planter. However, some machines had parts that could be used on such a planter. Some parts of the U.S. Department of Agriculture's grassland drill No. F–61 were also found to be suitable.[1] The suitable parts of these machines were incorporated into the design of the precision planter.

The precision planter was designed and constructed in 1958 by agricultural engineers of the Agricultural Research Service.

MACHINE REQUIREMENTS

Cooperating agronomists and engineers compiled the following list of desirable features the precision planter should have to meet research needs. These features were:

1. The planter should be tractor mounted and power operated.
2. It should be easily detached so the tractor can be used for other purposes.
3. It should have easy, quick adjustments so that a wide range of seed sizes and shapes can be planted.
4. It should have accurate seed placement and precise control of seeding rates ranging from single-seed planting to high-rate seed planting.
5. Each planter unit should be mounted independently so that it can follow the contour of the soil surface.
6. Each planter unit should be provided with positive, adjustable depth control.
7. Row width should be readily adjustable from 6 inches to 5 feet.
8. The planter units should be mounted in clear view of operator.
9. Rate of planting should be constant when either large or small quantities of seed are in the hopper.
10. A speedometer should be provided to allow operator to control ground speed while planting; counters should be available to show revolutions of the seed-metering wheel for use in calculating number of seed planted per foot of drill row.
11. Planter units should be equipped with double-disk furrow openers that are effective under many different conditions.
12. Each planter unit should have a packer wheel to firm the soil around the seed.
13. Packer wheels should be spring loaded so they will not lift the disk opener out of the soil.
14. Planter units should be constructed so they can be easily and thoroughly cleaned between different lots of seed.
15. Planter should be built with a fertilizer-placement applicator.
16. The fertilizer applicator should be built so that it can place fertilizer accurately above, beside, or below the seed.
17. Planter and fertilizer-placement attachment should be linked so they can be lifted as a unit with a single hydraulic cylinder.
18. The lift mechanism should provide for a minimum of 10 inches of clearance between the raised double-disk openers and the soil surface.
19. A vacuum clean-out tube should be provided for thoroughly removing seed and fertilizer from the machine between lots.

[1] The authors wish to express their appreciation to W. C. Hulburt and his staff in the Agricultural Engineering Research Division, Agricultural Research Service, for cooperation and design suggestions and for furnishing the complete fertilizer placement unit on the precision planter.

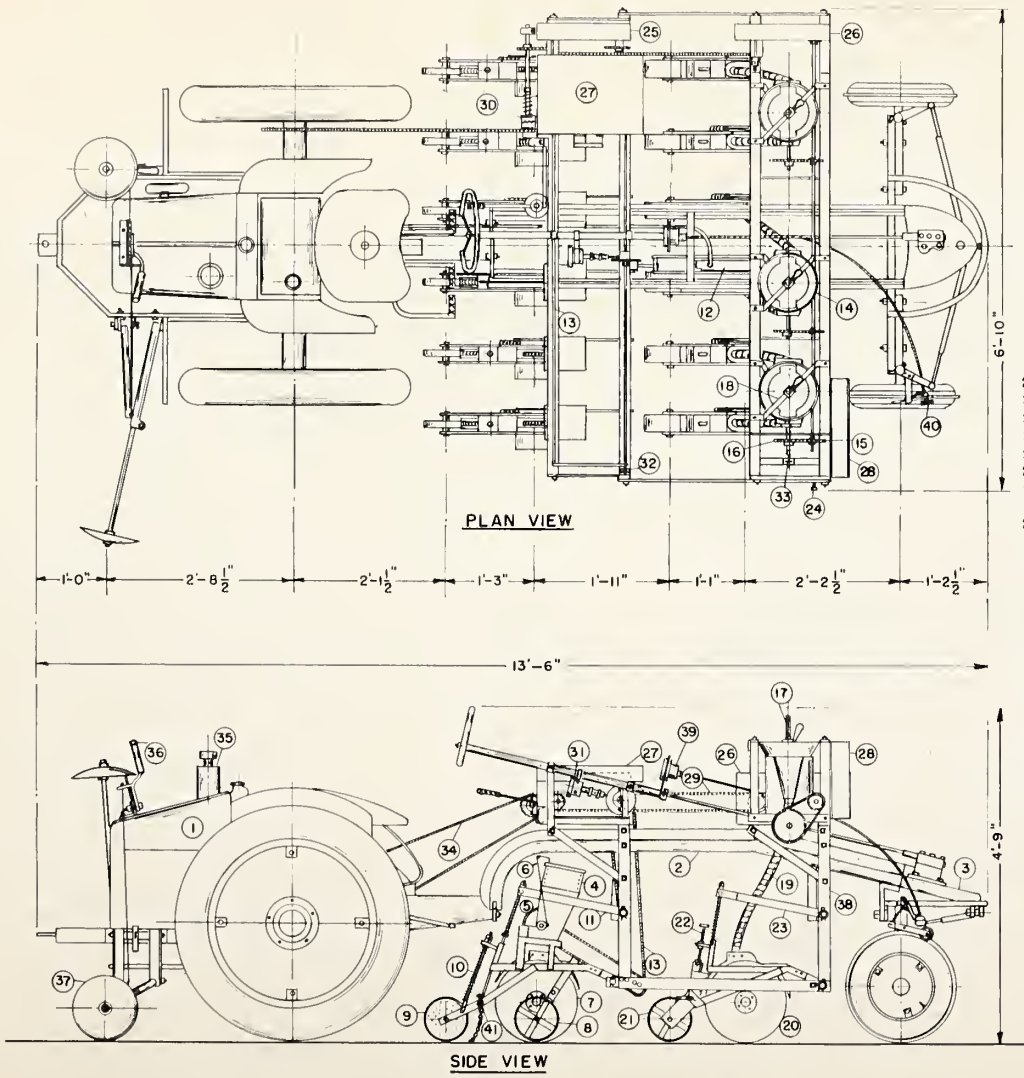
PRECISION PLANTER
1. MODEL "G" TRACTOR
2. REINFORCED EXTENDED MODEL "G" TRACTOR FRAME
3. MODEL "G" TRACTOR FRONT END
4. SEED HOPPER
5. SEED METERING WHEEL
6. SEED AGITATOR
7. DOUBLE DISK OPENER
8. DISK OPENER DEPTH CONTROL WHEEL
9. CEMENT-FILLED SPRING-LOADED SEED BED PACKER WHEEL
10. PACKER WHEEL ADJUSTMENT SCREW AND SPRING
11. PLANTER LIFT LINKAGE
12. 2"X 8" HYDRAULIC CYLINDER THAT POWERS PLANTER AND FERTILIZER LIFT LINKAGE
13. PLANTER DRIVE JACK SHAFT
14. 8" COLE TOP DELIVERY FERTILIZER HOPPERS
15. JACK SHAFT DRIVE FOR FERTILIZER METERING SCREWS
16. CHAIN DRIVE FOR FERTILIZER METERING SCREWS
17. FERTILIZER METERING SCREW
18. FERTILIZER RAKE-OFF BLADE
19. FERTILIZER DROP TUBE
20. FERTILIZER DOUBLE DISK OPENER
21. DEPTH REGULATOR WHEEL
22. DEPTH REGULATOR WHEEL ADJUSTING SCREW
23. LIFTING LINKAGE
24. SIDE ADJUSTMENT SCREW FOR FERTILIZER BAND PLACEMENT
25. GEAR TRAIN TO REGULATE THE R.P.M. OF THE SEED WHEEL
26. GEAR TRAIN TO REGULATE THE R.P.M OF THE FERTILIZER METERING SCREW
27. STORAGE FOR GEARS THAT REGULATE RATE OF PLANTING AND FERTILIZING
28. CARRYING CASE FOR CLEAN-OUT SUCTION HOSE
29. ROLLER CHAIN DRIVE FROM PLANTER GEAR BOX TO FERTILIZER GEAR BOX
30. SLIP CLUTCH FOR PLANTER DRIVE
31. SEED WHEEL REVOLUTION INDICATOR
32. SEED WHEEL REVOLUTION COUNTER
33. FERTILIZER SCREW REVOLUTION COUNTER
34. ROLLER CHAIN DRIVE FROM SPROCKET ON TRACTOR WHEEL TO PLANTER JACK SHAFT
35. SCREENED TRAP ON CLEAN-OUT SUCTION HOSE
36. FIELD MARKER CONTROL LEVER
37. FIELD MARKER
38. PLANTER AND FERTILIZER ATTACHMENT MOUNTING FRAME
39. SPEEDOMETER
40. SPEEDOMETER DRIVE
41. DRAG CHAIN
PLAN VIEW
1'-0"
2'-8 1/2"
2'-1 1/2"
1'-3"
1'-11"
1'-1"
2'-2 1/2"
1'-2 1/2"
13'-6"
10'-9"
SIDE VIEW
4'-9"

FIGURE 1.—Detailed drawing of precision planter and fertilizer applicator.

GENERAL DESCRIPTION OF MACHINE

Power Source

An Allis-Chalmers [2] rear-engine Model G tractor was used as the power unit. An extra front end was obtained, and its frame was lengthened and reinforced to accommodate the planter and fertilizer units (figs. 1 and 2). This assembly thus became the planting and fertilizing equipment that can be detached easily from the tractor. Easy detachability frees the tractor for use with other machinery that employs the standard front-end assembly. Detachment is facilitated by use of a chain hoist to keep the planter in position and by a two-wheeled screw jack to support the tractor and help move it from the planter to other equipment on which it can be used. The exchange can be made by one man in 30 to 45 minutes.

Planter Unit

Six precision single-row planters (Ventura Small Seed 1959 Model) were purchased and altered as required. This planter was chosen because it has a vertical seed-metering wheel that rotates in the seed chamber. The wheel is designed so it can pick up seed and drop it through a short tube into the furrow made by the disk opener (fig. 3). Each planter unit has space for two seed-metering wheels. Wheels that have peripheral cups large enough for only one seed are suitable for planting at low seeding rates. For high seeding rates wheels with large cups that can hold several seeds are used. The manufacturer provides wheels with different numbers and sizes of cups per wheel (fig. 4).

The seed chamber in which the metering wheels revolve is located below the seed hopper (fig. 3). Seed flows by gravity, aided by a seed agitator, from the hopper to the seed chamber. Flow from the hopper is regulated by an adjustable gate, which was rebuilt and graduated for greater accuracy. When the gate is properly adjusted, the amount of seed in the seed chamber should remain approximately constant while the planter is operating. The optimum quantity of seed that ought to be in the chamber for accurate planting is 15 to 20 cubic centimeters. When the seed amount is too small, the cups do not load well; when it is excessive, the cups frequently pick up too many seeds.

In field tests some difficulty was encountered because the aluminum metering wheel gouged the closely fitting aluminum block. The trouble was partly overcome by adding powdered graphite to

[2] Trade names are used in this publication solely for the purpose of providing specific information. Mention of a trade name does not constitute a guarantee or warranty of the product by the U.S. Department of Agriculture or an endorsement by the Department over other products not mentioned.

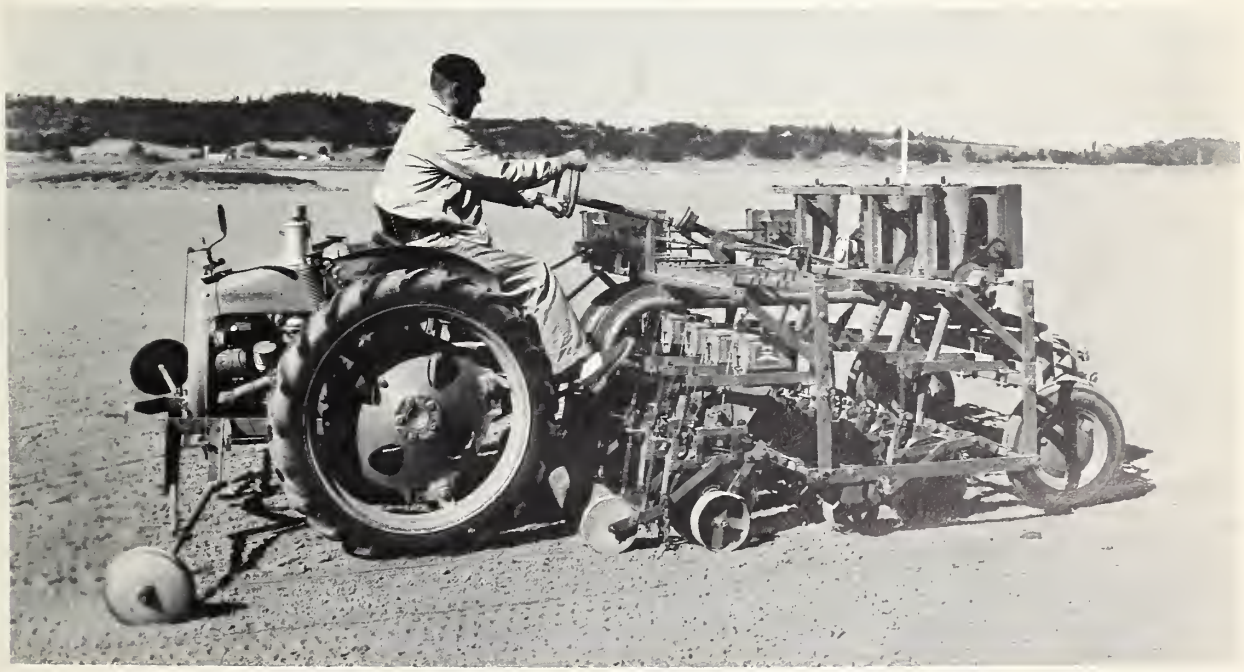

FIGURE 2.—General view of precision planter and fertilizer applicator. Planter units are mounted nearest the tractor drive wheels; fertilizer units are mounted ahead of the planter units.

the seed. However, the aluminum blocks were replaced later by plastic blocks, and these have eliminated the difficulty.

The rate of seeding is influenced by (a) the number and size of cups on the seed-metering wheel, (b) revolutions of the seed-metering wheel per foot of planter travel, (c) number of seed-metering wheels (one or two) used in each planter unit, and (d) the level of seed in the seed chamber.

The lowest seeding rate in a planter unit is obtained by using one blank wheel and one metering wheel that has the minimum number of single-seed cups and that rotates slowly. The planting rate is increased by replacing the blank wheel with a second metering wheel; by choosing wheels with more cups of larger size; and by speeding up the rotation of the metering wheel.

Because of the small quantity of seed that can be planted with this machine, planting rates are expressed in pounds of seed per acre and in live seeds per inch of drill row.

The shoe-type furrow openers originally on the planter units were well suited to seedbeds that are fine, smooth, and free from trash. However, to make the planter suitable for a wide range of seedbed conditions, the shoe openers were replaced by grain-drill, double-disk openers (figs. 3 and 5). Frameworks of the double-disk openers were redesigned to make the seed tubes perpendicular and allow seed to drop unimpeded to the soil (fig. 3).

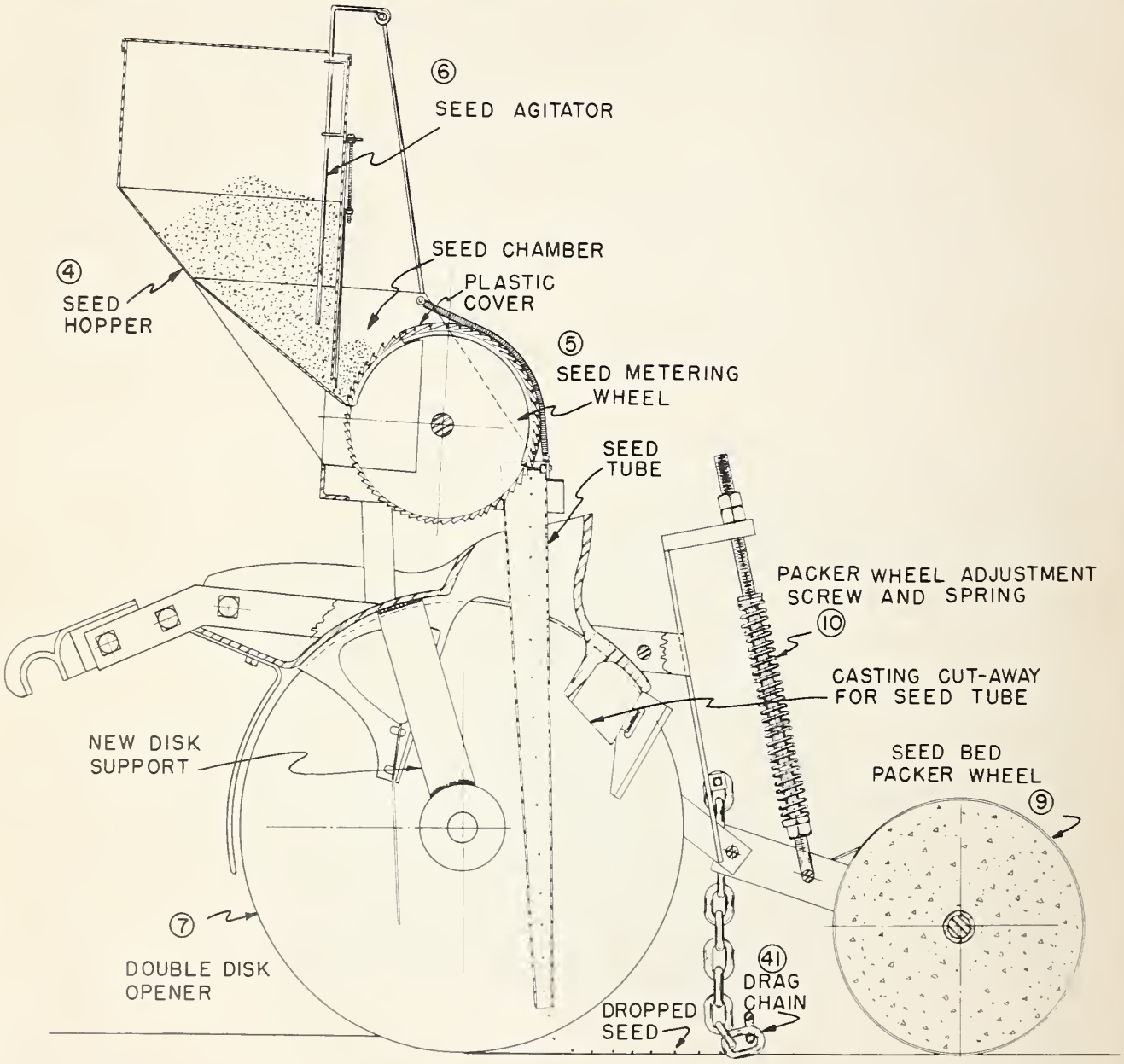

FIGURE 3.—Sectional view of a planter unit.

Seed is thoroughly covered by aid of drag loops made of ¼-inch welded-link chain placed behind the disk openers in front of the packer wheels.

Each planter unit has a spring-loaded, concrete-filled packer wheel (fig. 5) 1½ inches wide and 8 inches in diameter. Packer wheels follow the double-disk openers and firm a narrow strip of soil directly above and around the seed to promote quick germination and emergence of seedling. Quick emergence gives the crop seed an earlier start than the weed seed lying in loose soil on each side of the compressed strip. Other types of packer wheels that can be used are the semipneumatic, rubber-tired press wheels and split-center, concave-surfaced soil-firming wheels frequently used on commercial planters. For some conditions, the split center and concave surface of the latter type of wheel have the advantage of firming the soil on the sides of the seeded band while leaving the soil relatively uncompressed above the seed. This allows seedlings to emergence with the minimum of resistance.

When all planter units are mounted (figs. 2 and 3), the planter will drill six rows spaced 12 inches apart. Drilling of rows spaced 6 inches apart is done by drilling the middle of rows spaced 12 inches apart, using the packer wheel marks as guides. Planter units may be shifted from side to side or removed from the planter. They can be positioned on the machine so that an operator can plant two rows up to 5 feet apart; three rows up to 2½ feet apart; four rows up to 20 inches apart; and five rows up to 15 inches apart. An individual, separately adjustable, depth-control wheel mounted beside the double-disk opener (fig. 5) of each planter unit governs the depth of planting.

Planter units are mounted directly on top of the double-disk opener frames (fig. 5). The planter units were originally placed in a stationary position 23 inches above the double-disk opener, and the seed fell through flexible drop tubes. This arrangement was unsatisfactory because seed did not fall uniformly through the long tubes and caused frequent concentrations and skips in seed placement. The planter and fertilizer-disk openers are lifted and lowered hydraulically through mechanical linkage as a unit operated from the driver's seat by means of a control lever, tractor-powered pump, and a hydraulic cylinder.

Planter units can be emptied and cleaned between different lots of seed by use of a ⅜-inch flexible hose and a suction nozzle connected to the tractor intake manifold (fig. 6). Cleanings vacuumed from the hoppers are trapped in a removable 100-mesh screen basket in a metal chamber mounted on the oil-bath air cleaner of the tractor engine. The engine provides enough suction to pick up seed and fertilizer from the bottoms of the hoppers. Spring clips hold the hose-connected cap and screen in place on the air cleaner and allow quick removal and cleaning of the suction equipment. An adequate supply of clean oil in the oil-bath air cleaner prevents dust and trash entering the tractor engine.

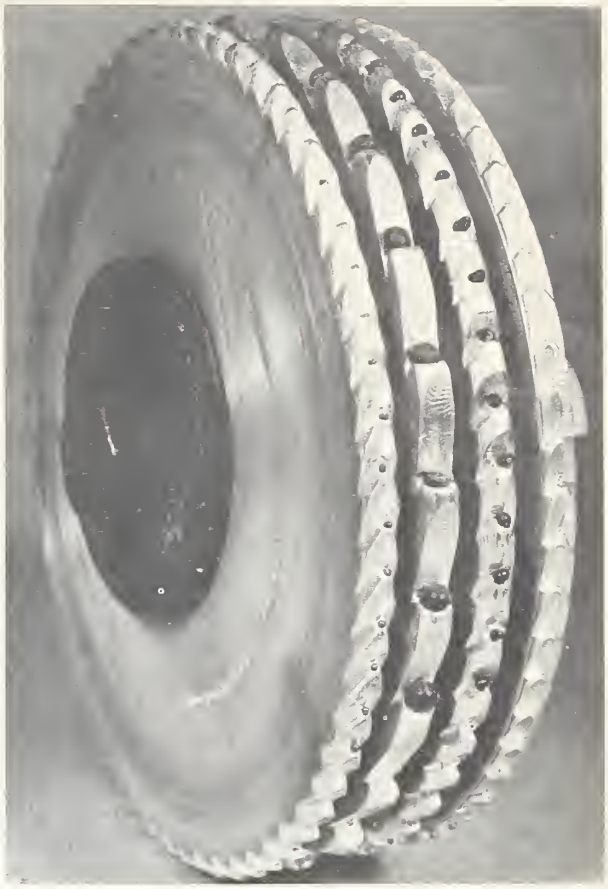

FIGURE 4.—Seed-metering wheels for different kinds of seed. Left to right—the wheels for birdsfoot trefoil, common vetch, subterranean clover, and white clover. Seeds of these plants are shown in cups.

Fertilizer Applicator

Fertilizer-placement equipment is used to apply fertilizer at planting time. Cole top-delivery type of metering device was used on the applicator (figs. 1, 2, and 6) because the device had been used satisfactorily for many years in fertilizer placement research by the U.S. Department of Agriculture's Planting and Fertilizing Equipment and Practices Investigations unit.

Fertilizer is metered by a revolving hopper that gradually raises the column of fertilizer as the hopper bottom moves up on a stationary center screw. Two stationary blades at the top, spaced 180 degrees apart, scrape fertilizer from the upward-moving column into separate delivery tubes. The fertilizer banding and placement mechanism is a grain-drill type of double-disk opener with a depth-regulator wheel (figs. 1 and 2). Six openers match the six seeding units and are as easily removed or adjusted for row width as are the seeding

units. The mounting shaft has a screw adjustment by which the whole assembly can be shifted to right or left of center when side placement of fertilizer is desired. This is an accurate and positive type of fertilizer application.

The fertilizer-placement units are mounted in front of the planters in full view of the operator and are lifted and lowered hydraulically along with the planter units. The principal value of having fertilizer-placement units on this planter is that seed and fertilizer can be applied in one operation, and fertilizer can be placed in bands near the seed. The rate of application can be easily and quickly changed by replacing gears in the gear box (See fig. 8, page 9) according to the desired rate of delivery (appendix table 2).

The lengthening of the tractor frame to accommodate the fertilizer applicators reduced maneuverability of the planter. However, by eliminating the variable fertilizer-placement feature, a standard front end and a combination disk opener could be used for planting and fertilizing, and thus increase the machine's mobility. A planter mounted on a standard length tractor is illustrated in the work of Klebesadel and Taylor.[3]

[3] KLEBESADEL, L. J., and TAYLOR, R.L. A SMALL VERSATILE TRACTOR-MOUNTED DRILL FOR EXPERIMENTAL PLOTS. Agron. Jour. 55: 206–207, illus. 1963.

CONTROLS FOR PRECISION

Forward Speed

The speedometer used on the plot planter is one commonly used on tractors and is driven from the right front tire of the tractor (figs. 1 and 2). The planter works well if driven at a speed of 1 mile per hour when drilling experimental plots. This is the speed at which most of the tests on the machine have been conducted. At this speed the operator can control the machine, observe the seeding units, and watch the fertilizer supply. Speed can be increased, but experience has shown that where precision work is paramount slow speed is imperative.

Revolution Indicator and Counter

The revolutions-per-minute indicator is a dial-type instrument on which the smallest graduation is 5 r.p.m. The indicator is driven by the planter-drive jack shaft (figs. 1, 2, and 6) and indicates the revolutions per minute turned by the seed-metering wheel. A revolution counter is installed at the end of the planter-drive jack shaft (fig. 5) for the dual purpose of checking accuracy of the revolution speed indicator and for determining the revolutions turned by the seed-metering wheel as

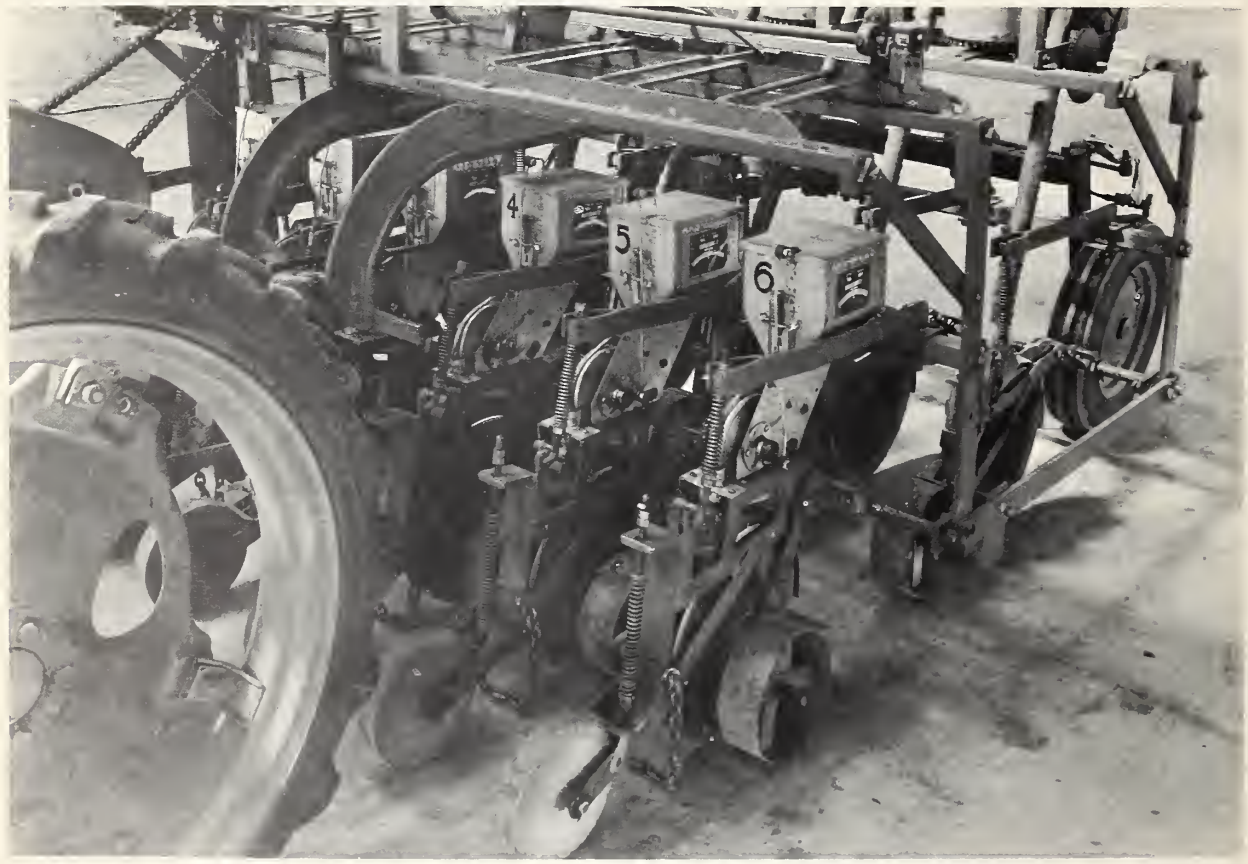

FIGURE 5.—Attachment of packer wheels and depth-control wheels to planter units.

the planter travels a given distance. Accurate operation of the revolution speed indicator is important at low planting rates. When the speed of the seed-metering wheel exceeds about 25 r.p.m., the seed cups throw seed forward, and precision of planting is diminished. Good operation has been obtained when the seed-metering wheels turn at a rate of 10 to 25 r.p.m. A revolution counter is also installed on the shaft that drives the revolving fertilizer-metering hopper (fig. 1) as an aid in checking the quantity of fertilizer that has been applied.

Flow of Seed From Hopper

The gate for regulating flow of seed from hopper to seed chamber is made up of two parts: (a) The main gate is adjustable by hand to ¼-inch graduations, and (b) a small gate on the face of the main gate is adjustable by a screw to 1/16-inch graduations (figs. 3 and 7). When planting clover and other small free-flowing seed, usually only the small gate is opened. Careful adjustment of the gate is required because an adequate supply of seed in the seed chamber is necessary for precise seeding. The gate should be accurately made and placed on each planter unit because an adjustment determined as appropriate for one planter unit should be applicable to all units when the drill is calibrated.

Gear Train

The gear train regulator for the planter units (fig. 8) consists of a combination of six steel gears (four visible) that control the revolutions of the seed-metering wheel per foot of ground travel. The gears are driven by a wheel-mounted sprocket on the tractor connected to gears by a chain. By using a series of gears, it is possible to have a wide selection of different seed-metering wheel speeds and to maintain an optimum speed of the wheel for any constant tractor speed. A similar gear set accurately regulates the flow of fertilizer by controlling the turning speed of the fertilizer hopper (fig. 8). Selection of the proper gear train for seeding and fertilizing is discussed in the Appendix.

Depth of Seed and Fertilizer Placement

Small seed should be sown in moist soil but not so deep that the seedlings cannot emerge. In seeding small-seeded legumes and grasses, probably more stand failures result from poor seedbeds and uncontrolled planting depths than from any other causes. Good stands usually result if fine, firm, smooth seedbeds have been prepared, and the depth of planting is properly controlled.

An adjustable depth-control wheel, 3 inches wide and 8 inches in diameter, is mounted on the right

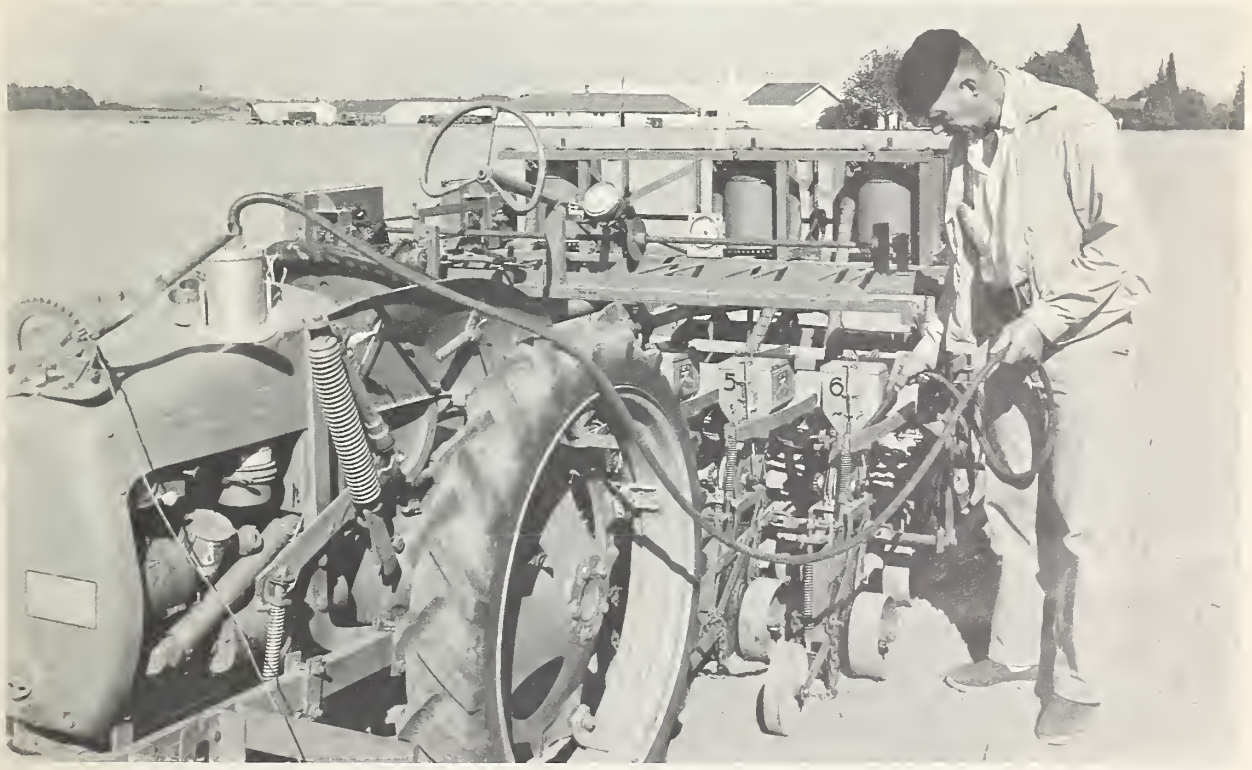

FIGURE 6.—Cleaning a seed chamber by use of a suction hose attached to tractor air cleaner.

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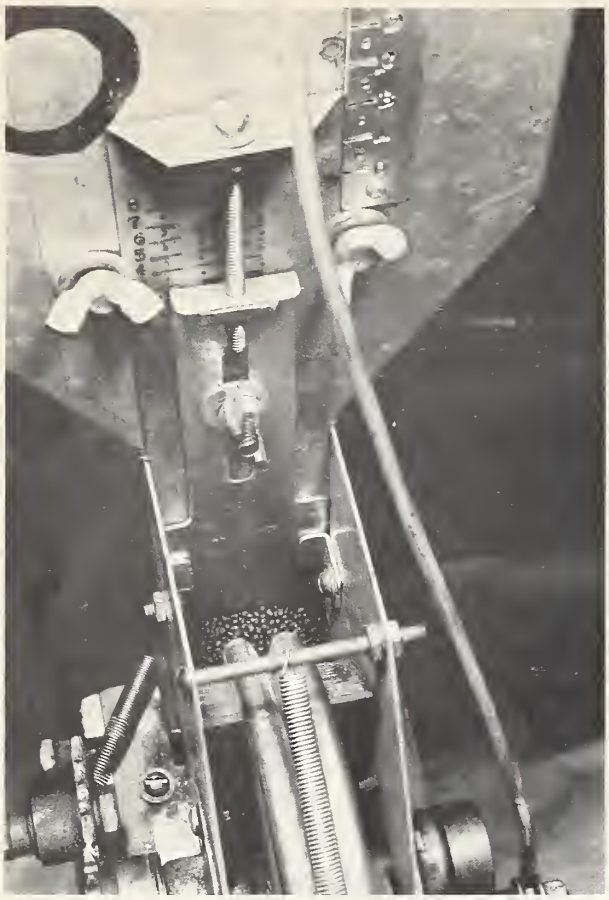

FIGURE 7.—Main gate and small gate for regulating the flow of seed from hopper to chamber.

side of each planting-unit double-disk opener in line with the center of the disk. With this arrangement, each planter unit can follow the contour of the soil independently of the other planter units and can place the seed at a uniform depth (figs. 2 and 5). This mechanism is very effective in controlling depth of planting on relatively smooth, fine seedbeds. To adjust planting depth, the disk openers are lowered onto a firm, smooth surface such as a plank or level floor. The depth-control wheels are then adjusted to the desired height above the plank or floor by using a wooden gage of the required thickness. The depth of fertilizer placement is controlled with a screw-adjusted depth-regulator wheel, which follows the double-disk fertilizer opener.

Seed-Metering Wheel

The manufacturer of the Ventura planter makes seed-metering wheels to order. The wheels are 5⅞ inches in diameter. The number of cups per wheel ranges from 6 to 60; cups range in size from those small enough to hold a single seed of whiteclover to large enough to hold a seed of common vetch (fig. 4).

Accurate shaping of seed cups on the seed-metering wheel is essential for precise planting, especially if whiteclover and other small seeds are to be sown at low rates that require the delivery of one seed per cup. A cup that is too shallow may not hold a seed. A cup that is too deep may pick up two seeds or become plugged with seeds that fail to drop out at the point of delivery. Ledges and crevices around the cups should be ground or filed smooth so that seed can not lodge and be lifted to cause variation in the intended planting rates. Precise delivery of seed is imperative when conducting an experiment on rates of planting.

To conduct experiments in which planting is done at a wide range in rate, several sets of seed-metering wheels differing in size of cup and in number of cups per wheel and a blank wheel are needed for each planter unit. Wheels that deliver one seed per cup are usable only when seeding at the lower rates. For the higher rates of planting, metering wheels with cups large enough to deliver two or several seeds are needed. The kinds of seed-metering wheels needed for each planter unit when planting birdsfoot trefoil at different rates are shown in table 1.

Field Marker

Uniform spacing of rows in areas wider than one drilled width of the machine is obtained by using single-disk markers mounted on the rear of the tractor (fig. 9). The control lever, mounted on a quadrant, can be operated from the driver's seat. The disks are connected to the lever by a cable, and as the lever is moved to lower one marker the other marker is raised. Telescoping pipe shanks allow various settings of the marker.

TABLE 1.—*Seed-metering wheels needed per planter unit for stated rates of seeding birdsfoot trefoil*

Live seed per linear inch of drill row	Seed-metering wheels per planter unit	Cups per wheel	Seeds per cup (approx.)	Movement of seed-metering wheel
Number	*Number*	*Number*	*Number*	*Rev./Ft.*[1]
1	1	60	1	0. 208
2	2	60	1	. 208
4	1	50	4	. 255
8	2	50	4	. 255
16	1	25	31	. 268

[1] From table 2.

CALIBRATION

Planter Unit

Precision of planting is increased if the seed is screened for size before the planter is calibrated. The largest and smallest seeds should be eliminated.

The first step in calibrating the planter is to determine the germination, purity, and the number of seeds per pound for the particular seed lot to be planted. Seeds per pound should be determined by counting seed and weighing the counted samples. One procedure is to draw three samples from the seed lot, determine the weight in grams of 1,000 seeds from each sample, and from this calculate the number of seeds per pound. Approximations of the number of seeds per gram may be obtained by referring to table 1, Rules and Regulations under the Federal Seed Act, U.S. Department of Agriculture, Agricultural Marketing Service, Service and Regulatory Announcements No. 156, Reprinted with amendments, August 1963. However, different lots of seed of the same species have been known to contain as much as 27.6 percent fewer to 16.6 percent more seeds per pound than the averages reported in Service and Regulatory Announcements No. 156. If precise planting is required, it is apparent that the number of seeds per pound in any given lot should be counted.

The second step in calibrating is to test one planter unit and determine the average number of seeds carried by the seed-metering wheel for the lot of seed to be planted. To do this, a crank is mounted in place of the metering-wheel drive sprocket and turned by hand. A few trials using a stop watch, or a watch with a second hand, will show the approximate turning speed required of the metering wheel. Fifteen to twenty cubic centimeters of seed should be maintained in the seed chamber while the metering wheel is turned at the rate of 20 to 25 r.p.m. The procedure consists of turning the seed-metering wheel five revolutions and catching and counting the seed. Five replications are used, making sure each time that the metering-wheel cups are full to the point of drop before beginning the revolution count. The average number of seeds per cup is calculated from the number of cups on the wheel.

The proper gear train to be used on the precision planter for various rates of seeding is determined by computing the revolutions of the seed-metering wheel required per foot of tractor travel (F) when the following values are known: The desired planting rate (A); row spacing (B); number of

FIGURE 8.—Gear trains that regulate the flow of fertilizer (left) and the revolving speed of seed-metering wheel (right).

seeds per pound (C); number of cups on the seed-metering wheel (D); and the average number of seeds carried per cup on the seed-metering wheel (E). The formula and its use and the procedure for selecting the proper gear train are explained in the Appendix.

A satisfactory alternate method to the one previously described is that of "trial and error." In this method one of the units while mounted on the planter is run over a strip of fine white masons sand. The sand is first placed on a clean, smooth surface and is then smoothed in a strip about 1 foot wide, a quarter of an inch thick, and 25 feet long (fig. 10). With the planter unit lowered so the disk opener barely clears the sand, the tractor is driven forward at field speed—about 1 mile per hour—and the pattern of seed distribution observed. Sampling counts of seed deposited on the sand should be made in three 3-foot linear segments and the average used to compute the rate of planting live seed per inch of travel and in pounds per acre. If the rate of planting needs altering, choose from table 2 in Appendix the gear-box ratio that will increase or decrease the delivery of seed to the desired rate. When the planting rate desired has been found, adjust the other planter units accordingly. No further calculation is needed for this particular planting rate.

Fertilizer Applicator

Each fertilizer unit has two drop tubes, one on each side of the hopper. As the column of fertilizer slowly rotates and rises in the hopper, two stationary blades scrape the fertilizer into the drop tubes. One blade of each pair is adjustable and can be regulated by trial and error until both blades scrape off the same amount of fertilizer. After being adjusted and set, the blades should not require readjustment. The rate at which the column of fertilizer rotates and rises determines the rate of fertilizer application. Fertilizer tubes not needed in an operation are made ineffective by use of buckets hung below the unneeded tubes to catch the fertilizer.

When using the attachable fertilizer applicator, the volume of fertilizer deposited through each fertilizer drop tube per linear foot of travel (J) can be computed if the following values are known: The weight per cubic foot of the fertilizer (I); the rate of application per acre (G); and

FIGURE 9.—A well-prepared seedbed. Single-disk markers are used to guide the operator when seeding areas wider than the planter.

spacing between bands (H). The formula and its use and the procedure for selecting the proper gear train are explained in the Appendix.

PLANTING TRIALS

Experimental plantings of ladino clover, red clover, birdsfoot trefoil, and alfalfa, have been made with the precision planter. All experimental planting rates were in terms of live seeds per inch, which quantity is readily converted to pounds per acre by using the weight-per-thousand-seeds values for the seed lots. Rates of 1, 2, 4, 8, and 16 live seeds per inch of drill row were intended for ladino and red clovers, birdsfoot trefoil, and alfalfa. These rates, however, were not always attained because seed-metering wheels with proper cup sizes for the higher planting rates were lacking. The calibrated rates of planting in terms of live seeds per inch and pounds of live seeds per acre in 6- and 12-inch rows are tabulated in the Appendix.

Highly satisfactory field plantings have been made with the following crops when seeded at approximately the following rates: (a) Birdsfoot trefoil, 4 pounds per acre in 12-inch drills; (b) red clover and alfalfa, 10 pounds per acre in 6-inch drills; (c) Kentucky bluegrass at one-half pound per acre in 3-foot rows; (d) orchardgrass and Chewings fescue, 1½ pounds per acre in 3-foot rows.

Precise planting at very low rates, like those attained with legume seed, was not possible with long, narrow grass seed because seed-metering wheels that can handle a single seed of this shape are not yet available.

Seed-metering wheels now available can be used for planting coated or pelleted single seeds of grasses at very low planting rates for research and for increase plantings of small lots of valuable seeds. To be satisfactory for precise planting, seed pellets must be approximately round, uniform in size and shape, and durable enough to hold together during handling and planting. The coating or pelleting material should be noninjurious to the seed.

CONCLUSIONS

A precision planter with a fertilizer applicator has been designed and constructed to meter seeds accurately at predetermined rates for experimental planting. Laboratory and field trials have shown that the planter can do this successfully with legume seed. Similar accuracy has not yet been achieved with long, narrow grass seed because of limitations in availability of seed-metering wheels that can handle seed of this shape.

These limitations can be overcome by coating such grass seed to near-roundness and uniformity of size.

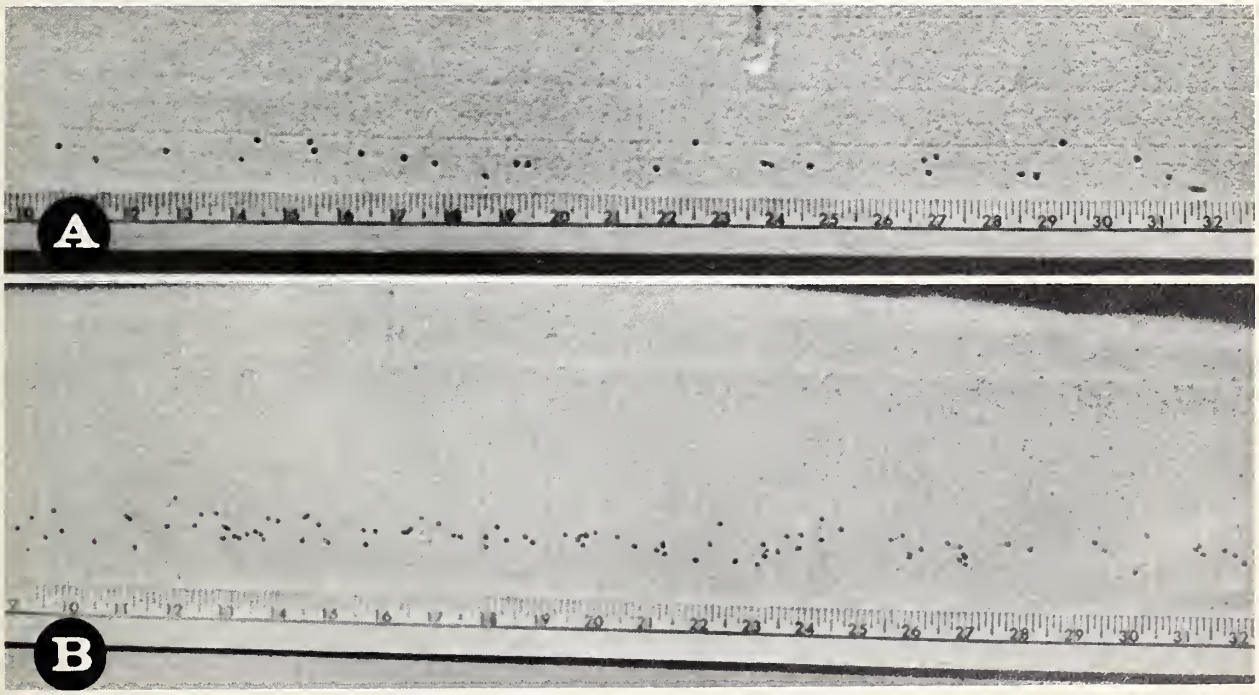

FIGURE 10.—Seed-distribution pattern from precision planter on white sand. In (A) the rate of seeding is approximately one live seed per inch; in (B) the rate is approximately four live seeds per inch. Both rates are based on a germination of 90 percent.

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APPENDIX

Computation Formulae and Gear-Train Selection

The procedures for computing the values of F (seeding) and J (fertilizing) and formulae symbols follow:

	Symbol
Desired planting rate—pounds per acre	A
Spacing between rows—inches	B
Seeds per pound—number	C
Seed cups on seed-metering wheel—number	D
Seed carried per seed cup (from calibration)—number	E
Revolutions of seed-metering wheel per linear foot of travel—number	F
Fertilizer application rate—pounds per acre	G
Spacing between bandrows of fertilizer—inches	H
Weight of fertilizer—pounds per cubic foot	I
Amount of fertilizer deposited per drop tube per linear foot of travel—cubic feet	J

The formulae for computing values of F and J are:

$$F=\frac{0.00000191307\times A\times B\times C}{D\times E}$$

$$J=\frac{0.00000191307\times G\times H}{I}$$

Examples of these computations and of selecting the proper gear-train combination follow.

For these examples, assume you wish to plant alfalfa, you have two seed-metering wheels each having 50 cups (D equals 100), and that the following seeding and fertilizing specifications are known: Planting rate, 6 pounds per acre (A); spacing between rows, 12 inches (B); number of seeds per pound of alfalfa, 220,000 (C); each cup carries 1.315 alfalfa seeds (E); the fertilizer application rate is 250 pounds per acre (G); the spacing between bands is 12 inches (H); and the fertilizer weighs 53.5 pounds per cubic foot (I).

With this information available, the computed value of F, according to the preceding formula, is 0.23044. In appendix table 2, the value of F nearest the computed value is 0.229, and the combination of gears (expressed in number of teeth per gear) the operator should use on the planter to seed alfalfa at the prescribed rate is 40, 72–72, 48–76, and 52.

The computed value of J is 0.0001072, and in appendix table 2, the value of J nearest the computed value is 0.000107. The proper combination of gears an operator should use to apply fertilizer at the prescribed rate is 80, 32–44, 76–52, 76.

TABLE 2.—*Precision planter gear-train combinations for stated F and J variables*

F (Revolutions of seed-metering wheel per linear foot of tractor travel)	J (Cubic feet of fertilizer deposited per drop tube per linear foot of tractor travel)	Gears for [1]—						Gearbox ratio [2]
		Shaft A (Driven)	Shaft B		Shaft C		Shaft D (Driver)	
			Rear	Front	Rear	Front		
0. 486	0. 000184	40	72	76	44	48	80	1. 73
. 483	. 000183	56	56	44	76	64	64	1. 72
. 479	. 000182	32	80	56	64	80	48	1. 71
. 477	. 000181	48	64	64	56	52	76	1. 70
. 467	. 000177	56	56	56	64	52	76	1. 67
. 466	. 000177	32	80	72	48	64	64	1. 66
. 461	. 000175	36	76	56	64	76	52	1. 65
. 460	. 000174	64	48	48	72	52	76	1. 64
. 454	. 000172	72	40	40	80	52	76	1. 62
. 449	. 000170	32	80	80	40	56	72	1. 60
. 447	. 000170	72	40	44	76	48	80	1. 59
. 441	. 000167	76	36	40	80	48	80	1. 57
. 435	. 000165	48	64	48	72	72	56	1. 55
. 431	. 000164	40	72	72	48	56	72	1. 54
. 426	. 000162	48	64	56	64	64	64	1. 52
. 419	. 000159	64	48	40	80	64	64	1. 50
. 418	. 000159	32	80	64	56	76	52	1. 49
. 414	. 000157	48	64	72	48	48	80	1. 48
. 411	. 000156	56	56	56	64	56	72	1. 46
. 408	. 000155	56	56	64	56	48	80	1. 45
. 405	. 000153	36	76	56	64	80	48	1. 44
. 402	. 000152	36	76	64	56	72	56	1. 43
. 399	. 000151	64	48	56	64	48	80	1. 42

See footnotes at end of table.

TABLE 2.—*Precision planter gear-train combinations for stated F and J variables*—Continued

F (Revolutions of seed-metering wheel per linear foot of tractor travel)	*J* (Cubic feet of fertilizer deposited per drop tube per linear foot of tractor travel)	Gears for [1]—						Gearbox ratio [2]
		Shaft A (Driven)	Shaft B		Shaft C		Shaft D (Driver)	
			Rear	Front	Rear	Front		
0.393	0.000149	40	72	56	64	76	52	1.40
.388	.000147	72	40	48	72	48	80	1.38
.382	.000145	56	56	40	80	76	52	1.36
.379	.000144	36	76	80	40	56	72	1.35
.375	.000142	56	56	44	76	72	56	1.34
.374	.000142	40	72	76	44	56	72	1.33
.368	.000139	40	72	80	40	52	76	1.31
.363	.000138	48	64	72	48	52	76	1.29
.360	.000136	48	64	76	44	48	80	1.28
.357	.000135	56	56	64	56	52	76	1.27
.353	.000134	36	76	64	56	76	52	1.26
.350	.000133	64	48	56	64	52	76	1.25
.345	.000131	40	72	56	64	80	48	1.23
.342	.000131	40	72	64	56	72	56	1.22
.340	.000129	76	36	40	80	56	72	1.21
.335	.000127	40	72	72	48	64	64	1.20
.334	.000127	76	36	44	76	52	76	1.19
.331	.000126	48	64	56	64	72	56	1.18
.327	.000124	80	32	40	80	52	76	1.16
.323	.000123	40	72	80	40	56	72	1.15
.319	.000121	56	56	56	64	64	64	1.14
.315	.000119	48	64	76	44	52	76	1.12
.310	.000118	48	64	80	40	48	80	1.11
.310	.000117	36	76	64	56	80	48	1.10
.306	.000116	36	76	72	48	72	56	1.09
.301	.000114	40	72	64	56	76	52	1.07
.296	.000112	72	40	56	64	48	80	1.05
.291	.000110	48	64	56	64	76	52	1.04
.290	.000110	76	36	48	72	52	76	1.03
.287	.000109	80	32	40	80	56	72	1.02
.282	.000107	80	32	44	76	52	76	1.00
.277	.000105	48	64	76	44	56	72	.99
.272	.000103	56	56	72	48	52	76	.97
.270	.000102	56	56	76	44	48	80	.96
.268	.000102	72	40	44	76	64	64	.95
.264	.000100	40	72	64	56	80	48	.94
.261	.000099	40	72	72	48	72	56	.93
.259	.000098	72	40	56	64	52	76	.92
.255	.000097	48	64	56	64	80	48	.91
.253	.000096	48	64	64	56	72	56	.90
.248	.000094	48	64	72	48	64	64	.88
.245	.000093	80	32	48	72	52	76	.87
.243	.000092	32	80	76	44	80	48	.86
.239	.000091	64	48	56	64	64	64	.85
.236	.000089	56	56	76	44	52	76	.84
.234	.000088	36	76	76	44	76	52	.83
.229	.000087	40	72	72	48	76	52	.82
.228	.000087	76	36	44	76	64	64	.81
.223	.000085	80	32	40	80	64	64	.80
.221	.000084	76	36	56	64	52	76	.79
.218	.000083	56	56	64	56	52	76	.78
.216	.000082	48	64	76	44	64	64	.77
.215	.000081	64	48	48	72	76	52	.76
.212	.000080	72	40	40	80	76	52	.76
.209	.000079	32	80	80	40	80	48	.75
.208	.000079	72	40	44	76	72	56	.74
.206	.000078	76	36	40	80	72	56	.73
.202	.000076	64	48	76	44	48	80	.72
.199	.000075	40	72	76	44	76	52	.71
.195	.000074	40	72	80	40	72	56	.70
.193	.000073	48	64	72	48	72	56	.69
.191	.000072	56	56	56	64	80	48	.68
.188	.000071	64	48	48	72	80	48	.67
.186	.000071	80	32	56	64	52	76	.66
.183	.000069	72	40	44	76	76	52	.65

See footnotes at end of table.

TABLE 2.—*Precision planter gear-train combinations for stated F and J variables*—Continued

F (Revolutions of seed-metering wheel per linear foot of tractor travel)	*J* (Cubic feet of fertilizer deposited per drop tube per linear foot of tractor travel)	Gears for [1]—						Gear-box ratio [2]
		Shaft A (Driven)	Shaft B		Shaft C		Shaft D (Driver)	
			Rear	Front	Rear	Front		
0.181	0.000068	76	36	40	80	76	52	.64
.178	.000067	76	36	44	76	72	56	.63
.174	.000066	40	72	76	44	80	48	.62
.172	.000065	72	40	72	48	48	80	.61
.169	.000064	76	36	64	56	52	76	.60
.167	.000063	56	56	64	56	76	52	.59
.164	.000062	80	32	56	64	56	72	.58
.162	.000061	56	56	76	44	64	64	.57
.159	.000060	76	36	80	40	48	80	.56
.156	.000059	76	36	44	76	76	52	.55
.153	.000058	80	32	40	80	76	52	.54
.150	.000057	80	32	44	76	72	56	.53
.147	.000055	76	36	72	48	48	80	.52
.145	.000055	48	64	80	40	72	56	.51
.139	.000053	56	56	80	40	64	64	.50
.137	.000052	76	36	44	76	80	48	.49
.136	.000051	76	36	48	72	76	52	.48
.133	.000050	72	40	72	48	56	72	.47
.130	.000049	80	32	48	72	72	56	.46
.127	.000048	80	32	56	64	64	64	.45
.124	.000047	80	32	72	48	48	80	.44
.121	.000046	72	40	56	64	76	52	.43
.119	.000045	76	36	48	72	80	48	.42
.116	.000044	80	32	44	76	80	48	.41
.113	.000043	76	36	72	48	56	72	.40
.110	.000042	56	56	76	44	76	52	.39
.109	.000041	80	32	72	48	52	76	.38
.108	.000041	80	32	76	44	48	80	.38
.105	.000040	72	40	64	56	72	56	.37
.100	.000038	80	32	48	72	80	48	.36
.099	.000037	72	40	80	40	56	72	.35
.097	.000036	56	56	76	44	80	48	.34
.094	.000035	80	32	76	44	52	76	.33
.090	.000034	76	36	56	64	80	48	.32
.087	.000033	80	32	56	64	76	52	.31
.085	.000032	76	36	80	40	56	72	.30
.083	.000031	80	32	76	44	56	72	.29
.079	.000030	76	36	64	56	76	52	.28
.076	.000029	80	32	56	64	80	48	.27
.074	.000028	80	32	72	48	64	64	.26
.071	.000027	80	32	80	40	56	72	.25

[1] Gear numbers indicate teeth per gear.
[2] Speed ratio of driven shaft to driver shaft.

Seed Used Experimentally in Precision Planter

Seed of the species listed in table 3 were sown by the precision planter at the stated rates per inch of drill row and pounds per acre in drills spaced 6 inches and 12 inches apart.

TABLE 3.—*Seed experimentally sown in precision planter*

Species and number of live seeds sown per inch of drill row [1]	Live seed per acre sown in drills spaced—	
	6 inches apart	12 inches apart
	Pounds	*Pounds*
Ladino clover:		
1	1. 2962	0. 6481
2	2. 592	1. 2962
4	5. 184	2. 592
8	10. 3696	5. 1848
16	20. 739	10. 3696
Red clover:		
1	3. 2942	1. 6471
2	6. 5084	3. 2942
4.08	13. 44	6. 72
8	26. 35	13. 18
15.09	49. 71	24. 86
Granger birdsfoot trefoil:		
0.95	3. 43	1. 72
1.9	6. 86	3. 43
3.99	14. 44	7. 22
7.99	28. 88	14. 44
16.4	59. 24	29. 62
Alfalfa:		
0.84375	3. 7852	1. 8926
1.6875	7. 5704	3. 7852
4.05	18. 1692	9. 0846
8.1	36. 3384	13. 1692
11.7374	52. 6570	26. 3285

[1] Features of these seeds were: Ladino clover, 806,543 seeds per pound, 81 percent germination; red clover, 317,358 seeds per pound, 91 percent germination; Granger birdsfoot trefoil, 289,248 seeds per pound, 93 percent germination; and alfalfa, 233,033 seeds per pound, 90 percent germination.

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